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**Goshgarian et al.**

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(54) **METHODS FOR RENAL  
NEUROMODULATION**

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(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,602,624 A 7/1986 Naples et al.  
4,649,936 A 3/1987 Ungar et al.  
(Continued)

**FOREIGN PATENT DOCUMENTS**

CN 2782017 5/2006  
CN 201356648 12/2009  
(Continued)

**OTHER PUBLICATIONS**

Allen, E.V., Sympathectomy for essential hypertension, *Circulation*,  
1952, 6:131-140.

(Continued)

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(57) **ABSTRACT**

Catheter apparatuses, systems, and methods for achieving  
renal neuromodulation by intravascular access are disclosed  
herein. One aspect of the present application, for example,  
is directed to apparatuses, systems, and methods that incor-  
porate a catheter treatment device comprising an elongated  
shaft. The elongated shaft is sized and configured to deliver  
an energy delivery element to a renal artery via an intravas-  
cular path. Thermal or electrical renal neuromodulation may  
be achieved via direct and/or via indirect application of  
thermal and/or electrical energy to heat or cool, or otherwise  
electrically modulate, neural fibers that contribute to renal  
function, or of vascular structures that feed or perfuse the  
neural fibers.

**14 Claims, 73 Drawing Sheets**

